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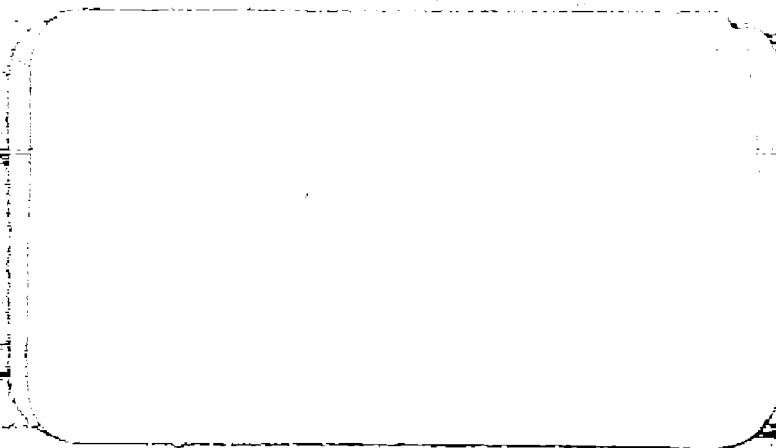
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MARINE ENGINEERING LABORATORY
ANNAPOLIS, MARYLAND - 21402

IN REPLY REFER TO:

NP/11345(833)
REPT 346/64

28 JAN 1965

FROM: COMMANDING OFFICER AND DIRECTOR
TO: CHIEF, BUREAU OF SHIPS (CODE 648E4)

SUBJ: MEL DEVELOPMENT PHASE REPORT 346/64, INVESTIGATION
OF PROPERTIES AND CHARACTERISTICS IN SHIPS OF THE U. S.
NAVY; TRANSMITTAL OF

- (A) BUSHIPS LTR 9300 SER 648E4-T160 OF 5 JUNE 1964
(B) MEL LTR NP/11345(833) OF 8 JUNE 1964

ENCLOSED HERewith IS MEL RESEARCH AND DEVELOPMENT PHASE REPORT
OF DETERMINATION OF THE QUANTITIES AND PROPERTIES OF SHIPBOARD
SEWAGE. THE PROJECT WAS AUTHORIZED BY REFERENCE (A). THIS REPORT CON-
TAINS INFORMATION WHICH CAN BE USED IN THE DESIGN OF A SEWAGE TREATMENT
UNIT FOR NAVAL VESSELS. IT CONCLUDES THE FIRST PHASE OF THE PROGRAM
REFERRED IN REFERENCE (B). WORK ON THE SECOND PHASE, THE EVALUATION OF
A CORRELATION-MATRIX FOR TYPE OF TREATMENT UNIT, IS CONTINUING.

E. M. Lerman

E. L. Lerman
By direction


(ENCLOSURE LIST, PAGE 11)

SURVEY TO DETERMINE QUANTITIES AND
PROPERTIES OF SEWAGE FROM NAVAL VESSELS

ASSIGNMENT 73 121
MEL RESEARCH & DEVELOPMENT REPORT 346/64
JANUARY 1965

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ABSTRACT

A SHIPBOARD SURVEY TO DETERMINE THE QUANTITIES OF HUMAN WASTES PRODUCED PER CAPITA AND THE PHYSICAL, BIOLOGICAL, BACTERIOLOGICAL AND CHEMICAL PROPERTIES WAS CONDUCTED TO ESTABLISH THE DEGREE OF POLLUTION OF HARBOR WATERS BY NAVAL VESSELS AND PROVIDE DESIGN CRITERIA FOR A TREATMENT SYSTEM. THE DATA SHOW THAT BETWEEN 10 AND 20 GPD OF SEWAGE ARE PRODUCED PER CAPITA ON SHIPS FOLLOWING A NORMAL WORKDAY ROUTINE. A MAXIMUM OF TWICE THIS AMOUNT CAN BE EXPECTED OF THE OPERATION IS ON AN AROUND-THE-CLOCK BASIS. THE SEWAGE PRODUCED CONTAINS AN AVERAGE OF 236 MG/L OF SUSPENDED SOLIDS AND AN AVERAGE BIOCHEMICAL OXYGEN DEMAND (BOD) OF 102 PPM. THE GEOMETRIC AVERAGE COLIFORM DENSITY INDEX WAS FOUND TO BE 4.8×10^5 . DATA IS ALSO PRESENTED FOR THE CONCENTRATION OF SETTLEABLE SOLIDS, TOTAL SOLIDS AND VOLATILE SOLIDS PRESENT. THE PH OF THE SEWAGE AND THE DISSOLVED OXYGEN PRESENT AND THE CONCENTRATION OF NITROGEN PRESENT IN VARIOUS FORMS WERE DETERMINED.

THE SURVEY ALSO SHOWED THAT THE WATER IN THE VICINITY OF A VESSEL FROM WHICH SEWAGE IS BEING DISCHARGED IS NOT POLLUTED TO ANY ADVERSE DEGREE IN TERMS OF THE COMMONLY USED PARAMETERS. VIRTUALLY NO SUSPENDED SOLIDS WERE FOUND IN THE RIVER WATER AND THE COLIFORM DENSITY WAS WITHIN THE RANGE PERMITTED AT MOST BATHING BEACHES IN THE UNITED STATES.

MEL REPORT 346/64

ADMINISTRATIVE INFORMATION

THIS WORK WAS PERFORMED AS A PART OF SUB-PROJECT S-F013 08 18, TASK 1892. IT WAS AUTHORIZED BY BUREAU OF SHIPS LETTER 9360 SER 648E4-396 OF 18 MAR 1964. THE ANALYTICAL WORK FOR THIS SURVEY WAS PERFORMED BY STRASBURGER & SIEGAL, INC., BALTIMORE, MARYLAND UNDER MEL CONTRACT N161-25944. ASSISTANCE IN THE EVALUATION OF THE DATA WAS OBTAINED FROM MR. J. HERNANDEZ OF HARVARD UNIVERSITY UNDER MEL CONTRACT 61533-475-65.

REFERENCES

- (A) STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTE WATER, 11TH EDITION, AMERICAN PUBLIC HEALTH ASSOCIATION, NEW YORK, 1960

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SURVEY TO DETERMINE QUANTITIES AND PROPERTIES OF SEWAGE FROM NAVAL VESSELS

1.0 INTRODUCTION

AS A CONSEQUENCE OF INCREASING PUBLIC AWARENESS OF WATER POLLUTION AND AUGMENTED RECREATIONAL USE OF TIDAL WATERS, THE NAVY IS HAVING TO FACE THE PROBLEM OF DISCONTINUING THE PRACTICE OF DIRECT DISCHARGE OF SEWAGE BY NAVAL VESSELS IN CONFINED WATERS. STANDARD PROCEDURES HAVE BEEN ADOPTED FOR THE SATISFACTORY DISPOSAL OF GARBAGE AND REFUSE; ALSO FEDERAL REGULATIONS AND INTERNATIONAL AGREEMENTS ARE EFFECTIVE IN CONTROLLING OIL POLLUTION BY SHIPS. THE PROBLEM OF SEWAGE DISPOSAL, HOWEVER, IS A VERY REAL ONE FOR WHICH NO CONCISE PRACTICAL SOLUTION HAS YET BEEN PROVIDED. THE TERM "SEWAGE," WHEN USED IN CONNECTION WITH SHIPBOARD DISPOSAL, IS LIMITED TO THE WASTE WATERS FROM WATER CLOSETS AND URINALS. THE PROBLEM IS CAUSED BY THE FOLLOWING FACTORS:

- THE CREATION OF A POTENTIAL HEALTH HAZARD FOR PEOPLE USING THE RECEIVING WATERS FOR RECREATIONAL PURPOSES.
- BACTERIAL POLLUTION OF SHELL-FISH BREEDING GROUNDS.
- DEPOSITION OF SOLIDS AND REDUCTION OF DISSOLVED OXYGEN LEVELS SO AS TO PRECLUDE OR IMPAIR AQUATIC LIFE.
- THE AESTHETIC ASPECTS OF UNSIGHTLY FLOATING SOLIDS AND ANY ASSOCIATED ODOR CREATE A NUISANCE TO PEOPLE USING THE WATERS AND ADJACENT SHORES.

2.0 BACKGROUND

A CONSIDERABLE AMOUNT OF WORK HAS BEEN DONE BY NASA AND OTHER AGENCIES TO DETERMINE THE QUANTITIES OF HUMAN WASTE PRODUCED PER PERSON AND THE CHEMICAL, BIOLOGICAL AND PHYSICAL PROPERTIES OF THIS WASTE. SHIPBOARD SEWAGE DIFFERS FROM DOMESTIC SEWAGE BECAUSE THE FLUSH WATER USED IN SEA WATER, BRACKISH WATER, AND IN LARGER QUANTITIES PER FLUSH.

THIS LABORATORY WAS REQUESTED TO PROVIDE THE FOLLOWING INFORMATION AS RELATED TO SHIPBOARD SEWAGE:

- HYDRAULIC DATA
- PHYSICAL DATA
- BIOLOGICAL DATA
- BACTERIOLOGICAL DATA
- CHEMICAL DATA

FOUR SHIPS, AN AIRCRAFT CARRIER, A DESTROYER, A CRUISER AND A SUBMARINE TENDER WERE SELECTED TO PARTICIPATE IN THE HYDRAULIC SURVEY. A SUBMARINE TENDER WAS SELECTED FOR OBTAINING THE REMAINDER OF THE DATA.

3.0 SHIPBOARD DATA

3.1 HYDRAULIC. REPRESENTATIVE AREAS ON EACH OF THE FOUR SHIPS WERE SELECTED FOR THE METERING OF FLUSH WATER. IN EACH CASE AN INTEGRATING FLOW METER WAS INSTALLED IN THE SEA WATER FLUSH LINE SUPPLYING FLUSH WATER FOR TWO WATER CLOSETS. RECORDING EQUIPMENT WAS SUPPLIED TO OBTAIN DATA ON THE TOTAL QUANTITY OF FLUSH WATER USED AND ON THE FREQUENCY OF FLUSHING. TABLE 1 SUMMARIZES THE INFORMATION OBTAINED FROM EACH SHIP.

TABLE 1

SHIP	NO. OF WATER CLOSETS METERED	NO. OF MEN USING WATER CLOSETS	AVERAGE TOTAL FLOW GPD*	PER CAPITA FLOW GPD		
				MAX	MIN.	AV.
USS ESSEX (CVS 9)	2	40	468			11.7
USS MULLINIX (DD 944)	2	20-30	299	15.0	10.0	12.5
USS NORTHAMPTON (CC-1)	2	20-30	377	18.9	12.6	15.1
USS FULTON (AS-11)	4 (1)		(2)			

(1) THREE WATER CLOSETS AND ONE URINAL

(2) DATA TO BE OBTAINED LATER

THE INFORMATION FROM EACH SHIP WAS OBTAINED OVER A 30-DAY PERIOD. IT WAS DETERMINED THAT ABOUT 4.5 GALLONS OF WATER ARE USED EACH TIME THE WATER CLOSET IS FLUSHED. PEAK FLOW PERIODS WERE EXPERIENCED BETWEEN 0500 AND 0900 HOURS AND BETWEEN 2100 AND 2300 HOURS. DURING THESE PERIODS THE FLOW RATE WAS BETWEEN 200 AND 300 PERCENT OF THE DAILY AVERAGE. SOME DAY-TO-DAY VARIATION WAS NOTED IN WATER USAGE DEPENDING ON THE OPERATING ROUTINE OF THE SHIP. ANOTHER FACTOR WHICH INFLUENCED THE WATER USAGE WAS THE NUMBER OF PERSONNEL HAVING LIBERTY. IF THIS NUMBER WAS GREAT AN ADDITIONAL PEAK LOADING PERIOD WAS EXPERIENCED BETWEEN 2400 AND 0100 HOURS.

3.2 PHYSICAL, BIOLOGICAL, BACTERIOLOGICAL AND CHEMICAL. SAMPLES OF HUMAN WASTES WERE COLLECTED ABOARD THE USS FULTON (AS-11) FOR PHYSICAL, BIOLOGICAL, BACTERIOLOGICAL AND CHEMICAL ANALYSIS. A CLOSED SAMPLED COLLECTION TANK EQUIPPED WITH A LOW SPEED STIRRER WAS INSTALLED IN THE STOREROOM BENEATH THE FORWARD CREW'S HEAD. THE SHIP'S PIPING WAS MODIFIED SO THAT THREE WATER CLOSETS AND ONE URINAL DRAINED INTO THIS SAMPLING TANK. THE CONTENTS OF THE TANK WERE AGITATED TO ASSURE THOROUGH MIXING. THE WASTE WAS COLLECTED FOR ONE HOUR AND WAS THEN SAMPLED THROUGH A QUICK OPENING VALVE. AFTER SAMPLING, THE CONTENTS OF THE TANK WAS DRAINED OVERBOARD PRIOR TO COLLECTING THE NEXT HOURS WASTE. TWENTY-FIVE SEWAGE SAMPLES WERE TAKEN OVER A THREE-DAY

*ABBREVIATIONS USED IN THIS TEXT ARE FROM THE GPO STYLE MANUAL, 1959, UNLESS OTHERWISE NOTED.

PERIOD. THE RESULTS OF THESE ANALYSES ARE SHOWN IN TABLE 2. IN ADDITION, SIX SAMPLES OF THE THAMES RIVER WATER USED FOR FLUSHING WERE ANALYZED TO ESTABLISH A BASE LINE FOR THE SEWAGE DATA. THESE RESULTS ARE SUMMARIZED IN TABLE 3.

4.0 DISCUSSION

4.1 HYDRAULIC DATA. DATA OBTAINED FROM THE THREE SHIPS SURVEYED SHOW THAT BETWEEN 10 AND 20 GALLONS PER DAY OF SEWAGE CAN BE EXPECTED PER MAN. LITTLE VARIATION WAS NOTED FROM SHIP TO SHIP. DURING PEAK PERIODS FLOW RATES AS HIGH AS 300 PERCENT OF THE DAILY AVERAGE CAN BE EXPECTED. THE U. S. ARMY CONDUCTED A SIMILAR SURVEY TO DETERMINE THE QUANTITIES OF SEWAGE PRODUCED AT A NIKE MISSILE SITE IN SHELTON, CONNECTICUT. IT SHOWED THAT AN AVERAGE OF 18.3 GPD COULD BE EXPECTED FOR EACH NONRESIDENT MAN AND 56.7 GPD FOR EACH RESIDENT. PEAK LOADING OF APPROXIMATELY 200 PERCENT OF THE DAILY AVERAGE WAS EXPERIENCED. SOMEWHAT HIGHER FLOWS WERE FOUND TO OCCUR AT A MISSILE SITE IN BEDFORD, MASSACHUSETTS. EACH NONRESIDENT USED APPROXIMATELY 26.2 GPD AND EACH RESIDENT APPROXIMATELY 74.2 GPD. PEAK LOADING OF ABOUT 250 PERCENT OF THE DAILY AVERAGE WAS EXPERIENCED. THE FLOW DATA FROM BOTH SITES FOLLOWED A TRIMODAL CURVE WITH PEAK FLOWS IMMEDIATELY AFTER MEAL TIMES OR EATING PERIODS. SUCH PEAKS WERE FOUND TO EXIST ABOARD NAVAL VESSELS. CONSIDERABLE QUANTITIES OF DATA WERE OBTAINED WHILE THE VESSELS WERE IN PORT. CUSTOMARILY IN THIS CIRCUMSTANCE A LARGE PORTION OF THE CREW GOES ASHORE PRIOR TO THE EVENING MEAL. THIS ACCOUNTS FOR LOWER FLOWS THAN WOULD BE EXPECTED WITH A FULL COMPLEMENT ABOARD DURING THE EVENING HOURS. BECAUSE ANY TREATMENT UNIT USED ABOARD A NAVAL VESSEL MUST BE DESIGNED TO OPERATE WITH A FULL COMPLEMENT 24 HOURS PER DAY, IT IS NECESSARY TO ADJUST THE PER CAPITA FLOWS OBTAINED IN THIS SURVEY. AS AN APPROXIMATION, IT IS ASSUMED THAT THE PER CAPITA FLOWS FOR 24-HOUR OPERATION CAN BE AS MUCH AS TWICE THOSE SHOWN IN TABLE 1.

4.2 PHYSICAL, BIOLOGICAL, BACTERIOLOGICAL AND CHEMICAL DATA.

4.2.1 SUSPENDED SOLIDS, BIOCHEMICAL OXYGEN DEMAND (BOD) AND COLIFORM DENSITY. AVERAGE VALUES OF SUSPENDED SOLIDS, BOD AND COLIFORM DENSITY WERE CALCULATED. ANALYSIS OF TABLE 3 SHOWS CONCLUSIVELY THAT THE HARBOR WATER ADJACENT TO FULTON IS NOT POLLUTED IN TERMS OF THESE COMMONLY USED PARAMETERS. THERE ARE VIRTUALLY NO SUSPENDED SOLIDS IN THE FLUSHING WATER AND A NEGLIGIBLE BOD. COLIFORM COUNT IS WITHIN THAT PERMITTED AT MOST BATHING BEACHES IN THE UNITED STATES.

THE VARIATION OF THE COLIFORM DENSITY INDEX IN THE SEWAGE SAMPLES RANGES FROM 4.3×10^2 TO 2.4×10^7 WITH LITTLE OR NO CORRELATION BETWEEN TIME OF DAY AND MINIMUM OR MAXIMUM VALUES. THE GEOMETRIC AVERAGE, ARITHMETIC AVERAGE AND MEDIAN COLIFORM DENSITIES WERE 4.8×10^5 , 3.1×10^6 AND 1.0×10^6 , RESPECTIVELY. THERE IS A GENERAL CORRELATION BETWEEN VALUES FOR SUSPENDED SOLIDS, COLIFORM AND BOD; ALL THREE FOLLOW THE SAME GENERAL PATTERN OF HIGH AND LOW VALUES. MUCH LOWER VALUES FOR BOD AND SUSPENDED SOLIDS WERE OBTAINED THAN ANTICIPATED. THE AVERAGE BOD FOR THE PERIOD OF SAMPLING WAS FOUND TO BE 102 PPM. THE AVERAGE LOAD OF SUSPENDED SOLIDS FOR THE PERIOD WAS 236 MG/L. THESE DATA INDICATE THAT THE WASTES COULD BE CLASSED AS A WEAK DOMESTIC SEWAGE.

TABLE 2

PHYSICAL, BIOLOGICAL, AND CHEMICAL ANALYSES OF SEWAGE SAMPLES
 TANK, 10000, USS FULTON (AS-11)

SAMPLE TIME AND DATE	DESCRIPTION OF SAMPLE	SUSPENDED SOLIDS MG/L	DIFFUSIBLE SOLIDS MG/L	pH	B.O.D. PPM	DISSOLVED OXYGEN PPM	TOTAL SOLIDS PPM	VOLATILE & ORGANIC SOLIDS PPM	SAMPLE NO.
1100 10-18-64	FLUSH WATER	0	-	7.60	0	6.85	32,594	4,906	1
1445 10-18-64	SEWAGE	52	3.0	7.39	30	4.70	33,038	5,028	2
1545 10-18-64	SEWAGE	0	1.5	7.11	75	5.45	31,998	5,044	3
1645 10-18-64	SEWAGE	30	7.5	7.29	39	5.50	38,940	11,014	4
1645 10-18-64	FLUSH WATER	0	-	7.70	5	6.70	31,742	4,240	5
2010 10-18-64	SEWAGE	198	6.0	7.31	80	2.80	31,678	4,636	6
2110 10-18-64	SEWAGE	790	6.0	8.20	225	3.50	31,890	5,006	7
0800 10-19-64	FLUSH WATER	0	-	7.71	1	6.70	33,520	6,814	8
0800 10-19-64	SEWAGE	802	1.0	7.15	240	1.90	40,524	13,828	9
0900 10-19-64	SEWAGE	154	3.5	6.45	195	6.80	35,022	7,730	10
1000 10-19-64	SEWAGE	14	2.5	7.25	107	6.90	31,556	4,226	11
1100 10-19-64	SEWAGE	224	12.0	7.30	180	5.60	32,042	4,884	12
1200 10-19-64	SEWAGE	214	7.5	7.21	97	5.00	33,746	6,512	13
1300 10-19-64	SEWAGE	250	3.0	7.10	103	5.10	31,634	5,210	14
1400 10-19-64	SEWAGE	100	2.0	4.60	110	2.80	33,756	6,306	15
1500 10-19-64	FLUSH WATER	0	-	7.59	2	6.60	33,488	6,952	16
1500 10-19-64	SEWAGE	306	4.0	7.10	29	6.00	34,610	4,582	17
1600 10-19-64	SEWAGE	94	1.5	7.30	42	6.00	31,610	5,012	18
1700 10-19-64	SEWAGE	202	12.0	7.15	62	5.80	32,008	5,016	19
1800 10-19-64	SEWAGE	166	7.5	7.25	57	6.50	32,830	4,666	20
0800 10-20-64	FLUSH WATER	0	-	7.61	0	6.50	32,040	4,582	21
0800 10-20-64	SEWAGE	132	4.0	7.40	51	6.70	32,304	5,182	22
0900 10-20-64	SEWAGE	336	0.8	7.95	115	5.55	32,144	4,928	23
1000 10-20-64	SEWAGE	88	0.4	7.70	18	7.35	31,746	5,120	24
1100 10-20-64	FLUSH WATER	0	-	7.69	0	6.10	31,900	4,450	25
1100 10-20-64	SEWAGE*	96	1.0	7.35	43	6.70	33,296	5,516	26
1200 10-20-64	SEWAGE	534	15.0	7.55	242	5.05	32,558	5,554	27
1300 10-20-64	SEWAGE	456	11.0	7.45	105	5.50	31,540	5,030	28
1500 10-20-64	SEWAGE*	66	5.0	7.70	6	7.10	32,152	4,836	29
1600 10-20-64	SEWAGE*	46	3.5	7.80	3	7.60	31,400	4,450	30
1700 10-20-64	SEWAGE*	14	2.5	7.65	4	7.90	32,008	4,768	31

*SAMPLE TAKEN DURING PERIOD WHEN HEAD WAS BEING CLEANED

TABLE 3

ANALYSES OF THAMES RIVER WATER USED FOR FLUSHING
ABOARD USS FULTON (AS-11)

SAMPLE No.	DATE & TIME	SUSPENDED SOLIDS MG/L	pH	BOD PPM	DISSOLVED OXYGEN PPM	TOTAL SOLIDS PPM	VOLATILE & ORGANIC SOLIDS, PPM	COLIFORM DENSITY INDEX COLIFORM PER 100 ML AT 35C
1	18 Oct 1100	0	7.60	0	6.85	32,594	4,986	93
5	18 Oct 1645	0	7.70	5	6.70	31,742	4,240	210
8	19 Oct 0800	0	7.71	1	6.70	33,520	6,814	1,100
16	19 Oct 1500	0	7.59	2	6.60	33,488	6,952	93
21	20 Oct 0800	0	7.61	0	6.50	32,040	4,562	430
25	20 Oct 1100	0	7.69	0	6.10	31,900	4,450	930

4.2.2 SETTLEABLE SOLIDS AND PH. THE SOLIDS APPEARED TO SETTLE RAPIDLY IN THE IMHOFF CONE TESTS. THE AVERAGE VALUE FOR THE THREE DAY SAMPLING PERIOD WAS 5.4 ML/L. THIS VALUE WAS ALSO LOWER THAN WOULD BE EXPECTED FROM DOMESTIC SEWAGE. THE PH OF THE HARBOR WATER WAS FOUND TO BE CLOSE TO THE OPTIMUM FOR BOTH BACTERIAL GROWTH AND FOR CHLORINATION REACTIONS. TWO LOW VALUES WERE OBTAINED ON 19 OCTOBER. LOW COLIFORM COUNTS WERE NOTED SIMULTANEOUSLY, INDICATING THAT CHLORINE OR OTHER CLEANING COMPOUND THAT WOULD LOWER THE PH MAY HAVE BEEN USED DURING THE PERIOD.

4.2.3 NITROGEN COMPOUNDS. THE NITROGEN VALUES REPORTED ARE A GOOD INDICATION THAT A WASTE HAS BEEN INTRODUCED INTO THE FLUSHING WATER. THE ORGANIC NITROGEN PRESENT WOULD BE EXPECTED TO CONTRIBUTE TO THE BOD OF THE WASTES. THIS OXYGEN DEMAND, HOWEVER, IS PROBABLY NOT COMPLETELY EXERTED DURING THE STANDARD FIVE-DAY BOD TEST, AS THERE DOES NOT APPEAR TO BE ANY CORRELATION BETWEEN THE BOD AND TOTAL NITROGEN VALUES REPORTED. HIGH VALUES FOR NITROGEN AS AMMONIA INDICATE THAT COMBINATION BETWEEN CHLORINE AND AMMONIA GROUPS MAY BE EXPECTED, THUS REDUCING THE AMOUNT OF FREE CHLORINE AVAILABLE FOR TREATMENT OF THE SEWAGE IF A CHLORINATION TREATMENT IS CONSIDERED.

4.2.4 VOLATILE SOLIDS AND TOTAL SOLIDS. MINERAL SOLIDS DUE TO SEA SALTS CONSTITUTE THE BULK OF THE TOTAL SOLIDS IN THE SEWAGE. AN AVERAGE OF 5825 PPM OF VOLATILE SOLIDS WERE FOUND. THIS VALUE REPRESENTS THE VOLATILE SOLIDS IN THE FLUSH WATER PLUS THE VOLATILE SOLIDS INTRODUCED BY THE SEWAGE.

4.2.5 DISSOLVED OXYGEN. THE SATURATION OXYGEN CONCENTRATION FOR WATER CONTAINING APPROXIMATELY 33,000 PPM SEA SALTS AT 16 C TO 19 C IS BETWEEN 7.7 AND 8.2 PPM. THE AVERAGE DISSOLVED OXYGEN CONCENTRATION OF THE FLUSH WATER USED WAS FOUND TO BE 6.61 PPM. THE AVERAGE DISSOLVED OXYGEN CONCENTRATION FOUND IN THE SEWAGE SAMPLES WAS 5.38 PPM. THIS DEPLETION OF 1.23 PPM IS NOT SERIOUS SINCE THE RESULTING CONCENTRATION IS STILL HIGH ENOUGH TO SUPPORT ALL FORMS OF SALT WATER MARINE LIFE.

5.0 SUMMARY

A SUMMARY OF THE CHARACTERISTICS OF SHIPBOARD SEWAGE IS PRESENTED IN TABLE 4 BELOW. ALTHOUGH ONLY ONE SHIP WAS SURVEYED TO OBTAIN THE PHYSICAL, BIOLOGICAL, BACTERIOLOGICAL AND CHEMICAL PROPERTIES, IT IS FELT THAT THESE VALUES ARE REPRESENTATIVE OF SEWAGE FOUND ABOARD ANY NAVAL VESSEL SINCE THE CONCENTRATIONS ARE LARGELY DEPENDENT ON THE QUANTITY OF FLUSH WATER USED. GOOD AGREEMENT WAS NOTED IN THE FLUSH WATER USAGE DATA OBTAINED FROM THE THREE SHIPS SURVEYED. ADDITIONAL FLUSH WATER USAGE DATA FROM THE USS FULTON WILL BE REPORTED WHEN IT BECOMES AVAILABLE. THE SEWAGE PROPERTIES PRESENTED IN TABLE 4 CAN BE USED AS INPUT PARAMETERS FOR THE DESIGN OF A TREATMENT SYSTEM FOR NAVAL VESSELS WITH THE EXCEPTION OF THE PER CAPITA WATER USAGE DATA. THESE VALUES SHOULD BE DOUBLED AS INDICATED ABOVE IN ORDER TO ALLOW FOR POSSIBLE ROUND-THE-CLOCK OPERATION OF THE SYSTEM.

TABLE 4

SUMMARY OF THE PROPERTIES OF SEWAGE
FROM A NAVAL VESSEL

PER CAPITA FLOW, GPD MAX.	17.0*
PER CAPITA FLOW, GPD MIN.	11.3*
PER CAPITA FLOW, GPD AV.	13.1*
SUSPENDED SOLIDS, MG/L AV.	236
BIOCHEMICAL OXYGEN DEMAND, PPM AV.	102
COLIFORM DENSITY INDEX, MPN PER 100 ML, GEOMETRIC, AV.	4.8×10^5
SETTLABLE SOLIDS, ML/L AV.	5.4
PH, AV.	7.38
NITROGEN AS AMMONIA, PPM AV.	15.2
NITROGEN AS NITRATE, PPM AV.	12.5
NITROGEN AS NITRITE, PPM AV.	0.01
NITROGEN, ORGANIC, PPM AV.	112.1
NITROGEN, TOTAL, PPM AV.	127.3
TOTAL SOLIDS, PPM AV.	33,000
VOLATILE AND ORGANIC SOLIDS, PPM AV.	5,825
DISSOLVED OXYGEN, PPM AV.	5.38

*THESE VALUES SHOULD BE DOUBLED TO ALLOW FOR AROUND-THE-CLOCK
OPERATION.

ACKNOWLEDGEMENT

THE ASSISTANCE OF COMCRUDESANT, COMNAVAIRLANT AND COMSUBLANT IN
MAKING THE ARRANGEMENTS FOR THIS SURVEY IS APPRECIATED. THE ASSISTANCE OF
THE OFFICERS AND CREWS OF THE USS FULTON, USS MULLINNIX, USS NORTHAMPTON
AND USS ESSEX IN INSTALLING THE EQUIPMENT AND RECORDING THE DATA IS ALSO
APPRECIATED.

<p>NAVY MARINE ENGINEERING LABORATORY REPORT 346/64</p> <p>SURVEY TO DETERMINE QUANTITIES AND PROPERTIES OF SEWAGE FROM NAVAL VESSELS, BY K. JAKOBSON AND M. J. POSNER, 19 JANUARY 1965, 13 PP. UNCLASSIFIED</p> <p>A SHIPBOARD SURVEY TO DETERMINE THE QUANTITIES OF HUMAN WASTES PRODUCED PER CAPITA AND THE PHYSICAL, BIOLOGICAL, BACTERIOLOGICAL AND CHEMICAL PROPERTIES WAS CONDUCTED TO ESTABLISH THE DEGREE OF POLLUTION OF HARBOR WATERS BY NAVAL VESSELS AND PROVIDE DESIGN CRITERIA FOR A TREATMENT SYSTEM. THE</p> <p>(OVER)</p>	<p>NAVY MARINE ENGINEERING LABORATORY REPORT 346/64</p> <p>SURVEY TO DETERMINE QUANTITIES AND PROPERTIES OF SEWAGE FROM NAVAL VESSELS, BY K. JAKOBSON AND M. J. POSNER, 19 JANUARY 1965, 13 PP. UNCLASSIFIED</p> <p>A SHIPBOARD SURVEY TO DETERMINE THE QUANTITIES OF HUMAN WASTES PRODUCED PER CAPITA AND THE PHYSICAL, BIOLOGICAL, BACTERIOLOGICAL AND CHEMICAL PROPERTIES WAS CONDUCTED TO ESTABLISH THE DEGREE OF POLLUTION OF HARBOR WATERS BY NAVAL VESSELS AND PROVIDE DESIGN CRITERIA FOR A TREATMENT SYSTEM. THE</p> <p>(OVER)</p>	<p>1. HARBORS - CONTAMINATION</p> <p>2. WATER-IMPUR.</p> <p>3. NAVAL VESSELS SEWAGE</p> <p>I. JAKOBSON, KUR</p> <p>II. POSNER, M. J.</p> <p>III. TITLE: SEWAGE FROM NAVAL VESSEL QUANTITIES AND PROPERTIES OF</p>	<p>DATA SHOW THAT BETWEEN 10 AND 20 GPD OF SEWAGE ARE PRODUCED PER CAPITA ON SHIPS FOLLOWING A NORMAL WORKDAY ROUTINE. A MAXIMUM OF TWICE THIS AMOUNT CAN BE EXPECTED OF THE OPERATION IS ON AN AROUND-THE-CLOCK BASIS. THE SEWAGE PRODUCED CONTAINS AN AVERAGE OF 236 MG/L OF SUSPENDED SOLIDS AND AN AVERAGE BIOCHEMICAL OXYGEN DEMAND (BOD) OF 102 PPM. THE GEOMETRIC AVERAGE COLIFORM DENSITY INDEX WAS FOUND TO BE 4.8×10^5. DATA IS ALSO PRESENT FOR THE CONCENTRATION OF SETTLEABLE SOLIDS, TOTAL SOLIDS AND VOLATILE SOLID PRESENT. THE PH OF THE SEWAGE AND THE DISSOLVED OXYGEN PRESENT AND THE CONCENTRATION OF NITROGEN PRESENT IN VARIOUS FORMS WERE DETERMINED.</p> <p>THE SURVEY ALSO SHOWED THAT THE WATER IN THE VICINITY OF A VESSEL FROM WHICH SEWAGE IS BEING DISCHARGED IS NOT POLLUTED TO ANY ADVERSE DEGREE IN TERMS OF THE COMMONLY USED PARAMETERS. VIRTUALLY NO SUSPENDED SOLIDS WERE FOUND IN THE RIVER WATER AND THE COLIFORM DENSITY WAS WITHIN THE RANGE PERMITTED AT MOST BATHING BEACHES IN THE U.S.</p>	<p>DATA SHOW THAT BETWEEN 10 AND 20 GPD OF SEWAGE ARE PRODUCED PER CAPITA ON SHIPS FOLLOWING A NORMAL WORKDAY ROUTINE. A MAXIMUM OF TWICE THIS AMOUNT CAN BE EXPECTED OF THE OPERATION IS ON AN AROUND-THE-CLOCK BASIS. THE SEWAGE PRODUCED CONTAINS AN AVERAGE OF 236 MG/L OF SUSPENDED SOLIDS AND AN AVERAGE BIOCHEMICAL OXYGEN DEMAND (BOD) OF 102 PPM. THE GEOMETRIC AVERAGE COLIFORM DENSITY INDEX WAS FOUND TO BE 4.8×10^5. DATA IS ALSO PRESENT FOR THE CONCENTRATION OF SETTLEABLE SOLIDS, TOTAL SOLIDS AND VOLATILE SOLIDS PRESENT. THE PH OF THE SEWAGE AND THE DISSOLVED OXYGEN PRESENT AND THE CONCENTRATION OF NITROGEN PRESENT IN VARIOUS FORMS WERE DETERMINED.</p> <p>THE SURVEY ALSO SHOWED THAT THE WATER IN THE VICINITY OF A VESSEL FROM WHICH SEWAGE IS BEING DISCHARGED IS NOT POLLUTED TO ANY ADVERSE DEGREE IN TERMS OF THE COMMONLY USED PARAMETERS. VIRTUALLY NO SUSPENDED SOLIDS WERE FOUND IN THE RIVER WATER AND THE COLIFORM DENSITY WAS WITHIN THE RANGE PERMITTED AT MOST BATHING BEACHES IN THE U.S.</p>
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